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Guest Editorial

Special Issue: Reconfigurable Wireless Communication Systems

By Fred Daneshgaran and Josef Noll, Guest Editors

The goal of the fourth-generation (4G) wireless systems is to provide broadband access to the mobile users: 'easier access to faster information services at any place', a goal that follows the introduction of multimedia services by IMT-2000 systems as, for example, UMTS and cdma2000. The future may provide truly broadband wireless access through such technologies as Mobile Broadband System (MBS) operating in the 40- and 60-GHz bands, interactive broadcast pseudosatellites and wireless access to Local Area Networks (LANs). Advanced antenna configurations and space-time processing leading to Multiple-Input Multiple-Output (MIMO) systems and the use of ever-increasing complex signal processing algorithms will squeeze evermore data through a given window of frequency. For mobility, seamless interoperability is the order of the day, and the wireless devices must be able to engage different systems using such diverse technologies as LMDS and MMDS, DVB, UMTS, IEEE802.11, Hiperlan, Bluetooth, xDSL and others. Within this context, In Software Radio (SR) promises to provide the flexibility and the interoperability capability needed for the future reconfigurable communication systems. The term Software Radio *SR* is used to encompass a wide range of agile, multimode, programmable radio systems that can operate over a wide frequency band and be able to 'speak' the language of the different protocols. The evolution in the semiconductor industry leading to constant increase in the clock speeds and increase in device density and the advent of reconfigurable hardware have paved the way to the creation of SR platforms. SR uses a mix of hardware entities for the implementation of radio transceiver functions capable of commanding the Radio Frequency (RF) spectrum.

The collection of papers in this special issue encompasses a wide range of scopes and topics. The aim has been to capture a snapshot of the current state of R&D activities in this very fertile field, yet at the same time provide the basis of the why and how of SR through several tutorial papers and example applications. Note that the terms 'software radio' and 'reconfigurable systems' are essentially synonymous. As is often the case, from time to time the commonly used term changes with the fashion of the day. At the time of this writing, 'Reconfigurable Systems (RS)' tend to be more fashionable. The ferment in any area is often driven by economic factors. This is indeed true with RS in which the driving force in several segments of the industry is economics. In mobile radio systems there are significant benefits to the construction of Base Transceiver Stations (BTS) in RS technology. This allows the operator to invest in an adaptable technology that allows it to perform system upgrades, create nodes capable of interoperating between different protocols or even completely change the communication protocol without the necessity of investing in a completely new hardware infrastructure. In the automotive industry where the role of infotainment is becoming ever more important, the RS technology can offer significant cost benefits and a whole array of location-dependent services that could not otherwise be offered, or offered at a significantly higher cost to the customer. The list goes on and the trend in migration from fixed architecture systems to RS continues.

The papers in this special issue are of three basic categories: Tutorial (T), Application-oriented (A) and Research papers (R). We shall use the appropriate symbol when introducing the papers in what follows. The paper by Noll *et al.* (T) provides a perspective on the system requirements for supporting future-generation protocols and services from an operator point of view. The paper presents a scenario of the potential mobile wireless services demanded by the user on the basis of on his/her profile, the key

element being the ability to roam and interoperate in a heterogeneous network of diverse devices supporting a variety of protocols yet receiving a user-defined set of services that are transparent to the user regardless of location and access protocol. In this vision, the RS terminal is a central element. The authors then draw an evolutionary path from the fixed architecture hardware devices supporting single protocols to truly universal RS terminals.

The paper by Cianca *et al*. (T) presents an update on the status of R&D and the current thinking of how the somewhat inflexible networks of today may evolve to support the services demanded of the future generation of wired and wireless communication systems. In particular, the paper delves into the concepts of adaptivity at the physical layer of the protocol stack via adaptive coding, modulation and Automatic Repeat Request (ARQ), and presents the argument for the need of an across-layer optimization that addresses the interplay of the physical and the upper layers of the protocol stack to support the future generation of services more efficiently and cost-effectively.

In the paper by Laddomada (T), the author addresses a very interesting issue often overlooked in the literature on RS. In particular, assuming that a universal RS user terminal is available, an interesting issue is how would such a universally programmable unit receive its program and operational software? Or for that matter, what typology of software blocks, routines and so on should be defined for a universally programmable device? The paper addresses both the issues of a potential software architecture for such a programmable unit and looks at different mechanisms of software download, providing a qualitative comparison of various techniques.

The paper by Dovis *et al*. (A) looks at a very interesting application of the RS to the design and implementation of an interoperable localization receiver. The Galileo system that is currently being developed in Europe is essentially envisioned to provide precise localization services for commercial applications. It is to be an alternative to the Global Positioning System (GPS), which is controlled by the United States. GPS cannot offer a reliable localization service owing to the fact that it may be occasionally inaccessible to the civilian users at times of crisis or as needed by the US military. Hence, no commercial enterprise has embraced its use to offer location-dependent services. The paper presents details of the architecture and algorithms used for the implementation of a prototype receiver implemented using reconfigurable logic and Digital Signal Processing (DSP) boards. Such a receiver would be capable of interoperating between GPS and Galileo systems, in addition to offering the possibility of integration of various localization signals to improve performance. Simulation results obtained with the prototype receiver are also presented in the paper.

In the paper by Mondin *et al*. (A), the authors present another very interesting application of the RS technology to the design and implementation of a Satellite and/or Unmanned Aerial Vehicle (UAV) transponder or signal processing payload. The use of RS in such applications offer significant advantages in comparison to the traditional fixed architecture systems. Current trends in satellite technology are toward implementation of smaller, cheaper and lighter mini- and micro-satellites that can significantly reduce the upfront costs associated with the platform launch into the orbit. In addition, there is a steady move toward the use of Commercial Off The shelf (COTs) and Commercial Avionics Military (CAM) hardware for construction of the satellite payload, as opposed to the use of radiation-hardened, often very expensive hardware that technologically lag behind their terrestrial counterparts by several device generations. These trends in addition to the significant cost benefits offered by reconfigurable payloads favor the eventual deployment of the RS technology in the space sector.

The paper by Falletti *et al*. (R) is a research paper in the general area of MIMO systems. In particular, the paper looks at a promising new blind technique for spatiotemporal signal processing of Direct Sequence (DS) Code Division Multiple Access (CDMA) signals. The CDMA technology in addition to multicarrier modulation based on Orthogonal Frequency Division Multiplexing (OFDM) have become the *de facto* multiple access technologies of choice for many wireless applications. This is due to their inherent robustness to time-varying multipath channels and flexibility of use for offering a variety of services with diverse data rate requirements. The most common architecture for the CDMA receiver utilizes a RAKE receiver, whereby the multipath components of the desired signal are coherently combined at the receiver. The paper looks at a novel solution to the Multiple Access Interference (MAI) problem by combining blind adaptive beamforming techniques, with RAKE processing in an architecture resembling a wideband beamformer. Simulation

results are presented demonstrating the potential gains of this promising technique.

Finally, the paper by Daneshgaran and Laddomada (R) looks at a novel decimation filter design technique for Sigma-Delta (Σ-Δ) Analog to Digital Converters (ADC). The creation of a true RS unit requires moving the analog-to-digital boundary of the system as close to the antenna as possible. This way, digital processing can begin as early as possible in the processing chain, providing the greatest degree of flexibility in the reconfigurable device. Unfortunately, direct digitization of the RF signals has a significant power penalty in addition to placing great demands on the ADC. Yet, direct digitization of the RF signal is a waste of system resources since the intelligence signal often occupies a narrow band of frequencies around the RF carrier. The Σ-Δ ADC architecture offers the greatest promise in terms of providing the possibility of direct digitization of the intelligence signal around the RF carrier frequency (i.e. the process of frequency translation is embedded in the system architecture). A key element in the design of such converters is the rate-conversion filter, which is responsible for shaping the output noise spectrum and rejection of the out-of-band noise. This research paper presents a novel hardware efficient architecture for a class of rate-conversion filters suitable for the design of wide-band Σ-Δ ADCs.

Enjoy the special issue!!

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